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Economic & political factors for renewable energy in the United States

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Economic & Political Factors for Renewable Energy in the United States

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Jeremiah Daniel Yokley

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Abstract

The results of this study provide some insight to how qualitative regime variables affect the production of renewable energy in the United States. Specifically this paper found that while working with other variables the political affiliation of the President of the United States and the party holding the majority of seats in the United States House of Representatives and Senate can aid in forecasting renewable energy production growth. With this insight it is possible to better prepare for future energy investments by either governments or the private sector. This paper specifically examines total renewable energy production, hydroelectric energy production, solar energy production, wind energy production, other forms of renewable energy production such as geothermal and biomass. Examining regime variables was especially useful in solar and wind production.

Introduction

Harnessing the power of energy to promote the needs of humanity is unquestionably one of the greatest advancements of humankind. So great is this achievement that it has since encompassed everyday life for everyone. Electricity is essential to modern human life. Because of our understanding of this monumental resource many have been freed from the laborious methods of an archaic age long gone. The tradeoff that counters this, as is always present in the economic evaluation of any situation, is the negative externalities that present themselves in light of this magnum achievement. Therefore it is important to understand how economic and political forces effect the production of this resource. Truly, there is no such thing as a free lunch. The adverse consequences were first heralded at the dawn of the industrial age with, understandable, a certain degree of trepidation as the entire world transformed into a brand new kind of creature by mechanical design alone. Where production was once controlled by the sheer might of man and beast alone, now the lingering presence of gigantic contraptions towered over the great industrial centers of the world. Steam and electric powered motors enabled the coming of a new era now dominated by capital. The fundamental shift that occurred at this time shook the world. Cities exploded into existence and suddenly new ideas of consumption were conceived by the masses. Conversely many perceived this new age as one of degradation and dehumanizing. It was in this industrially lit environment that those such as Karl Marx recognized the plight of the proletariat. Viewing existence through these lenses, those who were once free to work as they pleased now fell under the perceived yoke of a capitalistic master in a horrific reincarnation of industrial servitude. In order to survive in this dystrophic new world the many sacrificed their livelihoods for the pleasure of the few bourgeoisies who wielded the new mechanisms that now fueled society.

Though the moral degradation of society is a more subjective concept that is difficult to define or truly understand by any universal account, other externalities quickly became much more apparent such as pollution. These unforeseen environmental impacts became a part of everyday life as a product of economic advancement.

The pages of history were continuously printed on the press of industrialization from its onset to the present. Our recent history mirrors many aspects of centuries ago. To understand this, one has only to look at China and her most recent rise to glory. Personal Incomes and Gross Domestic Product (GDP) in this country have been climbing at quite impressive rates. Materially, for the population of this East Asian leviathan, this has meant higher standards of living as measured by the traditional methods, namely GDP per capita. However, China is not immune to the consequences of this new found affluence. Last year China usurped the United States as the world's largest contributor of carbon emissions. India is following suite and will soon be in the same straits as their oriental neighbor.

The vast majority of pollution is measured in carbon dioxide and most of the CO2 in the atmosphere is directly derived from the use of motor vehicles. The second largest emission mechanism for these greenhouse gasses is power generation. Many of the externalities associated with fossil fueled powered electricity generation are harmful to humans and society as a whole. Given the present state of the world, renewable energy options would most certainly prove a better option to pursue. A greater utilization of renewable energy would mean cleaner air, cleaner water, lower medical costs from pollution related illnesses and perhaps even more stable energy prices. Thus renewable energy options would prove more beneficial to society providing the energy for an ever more productive world without the negative consequences of fossil fuel generation.

The problem that arises is determining what variables affect the growth of renewable energy production. Properly determining these variables could shift the composition of a country's energy portfolio to introducing a shift to larger contributions from cleaner, renewable energy sources. If this shift in the energy portfolio were to occur, nearly everyone would benefit from lower levels of pollution and less dependency on fossil fuels. Additionally, producing more energy from renewable sources would preserve more resources for future generations.

The hypothesis presented in this paper is that combinations Democratic control of the Presidency, House of Representatives, and the Senate in the United States will affect the production of renewable energy. Democratic Vice President Al Gore was perhaps the most vocal on the subject in recent history. As early as 1989, Gore wrote in the Washington Post that the United States should, "focus on producing energy for development without compromising the environment" (Gore, 1989). Gore continued on to be one of the most outspoken proponents of renewable energy technology. Contrary to this sentiment, in 2009 and 2010 Republicans in congress were proposing drastic cuts in renewable energy incentives to alleviate budget deficits (Hube, 2011). A determination of the effects of some of these qualitative variables can enable voters, interested corporations, and policy makers to understand and make more educated choices as elections allow for different party control in the future.

Brief History of Fossil Fuels

Along with the gigantic scale of production that was inherently witnessed during the onset of mass production, came a shift in the power source needed by industry. This, of course came in the form of fossil fuels. Initially the hydrocarbon of choice for world industries was wood. Wood was fairly abundant, but most importantly, easily accessible to the majority of the world's population with the new endowment of productive capacity. But specifically, this resource was within close proximity to the burgeoning industrial centers that came to be during the industrial revolution. Because of its better efficiency, fossil fuels became the king of industry (Foley, 1985). In the relatively recent past in America, fueling industry was quite an easier task to accomplish. Since the first commercial oil well was utilized in Titusville, Pennsylvania in 1859, our energy demands have by and large been met by the most simplistic of means (Owen, 1975). This was the broad policy of the United States since the turn of the century. Now, in contemporary society, many of these notions are being questioned - primarily, since the research conducted by Marion King Hubbert for the Shell Company (Donnelly, 1987). Hubbert, the most noted geologist of his time, noted that the production of fossil fuels would peak in the United States around the turn of the century, which did come to pass, and that the United States would slowly but definitely use up the rest of its untapped oil reserves in the next century, being the twenty first century, and a half or so.

In September of 1960, the five founding members of the Organization of Petroleum Exporting Countries organized a cartel in order to protect them from being exploited more prominent, militarily superior, members of the global community. And in the 1970's this fledgling organization flexed its economic muscle for the first time. The oil embargo of the 1973 threw the United States into an unprecedented chaos. Workers feared for loss of their jobs while also mentally confronting the need to earn enough disposable income to purchase the relatively more expensive food to feed their families. It was in the wake of these turbulent times that the widespread notion of domestically produced renewable energy first entered the political culture of the average American citizen. Then President Carter offered up an ambitious energy policy to switch the economy of the United States from a fossil fuel based economy to one that was based on renewable energy. Even with like-minded Democrats controlling both houses of congress at the time, Presidents Carter's pleas fell on a deaf audience. Americans, likewise, continued to do what they do best: they persevered. With the passage of time, wounds healed and generations forgot. Now in the onset of the Twenty-first Century the same problems of the Twentieth Century act as continued annoyances. In 2011, most of the world still survives largely in a carbon based economy.

In more recent years that were examined in this paper, the different parties have taken very specific views in the field of renewable energy. Democrats specifically have supported switching from the traditional hydrocarbon structure to support renewable energy instead (Mufson, 2007). Presidents are less cut and dry since the early nineteen nineties. President George W. Bush and the Republicans obviously favored expanding current fossil fuel production at the cost of expanding renewable energy (Rogers, 2011). The current stated policy of the Democratic Party according to their website is "Democrats have made historic investments in clean-energy technologies that are helping pave the way to a more sustainable future, creating new jobs and entire industries here in America. We believe that now is the moment for this generation to embark on a national mission to unleash America's innovation and seize control of our own destiny" ("Energy independence," 2011). The rhetoric of the Republican party website is similar stating, "We support an 'all the above approach' that encourages the production of nuclear power, clean coal, natural gas, solar, wind, geothermal, hydropower, as well as supporting offshore drilling in an environmentally responsible way." ("Energy," 2011).

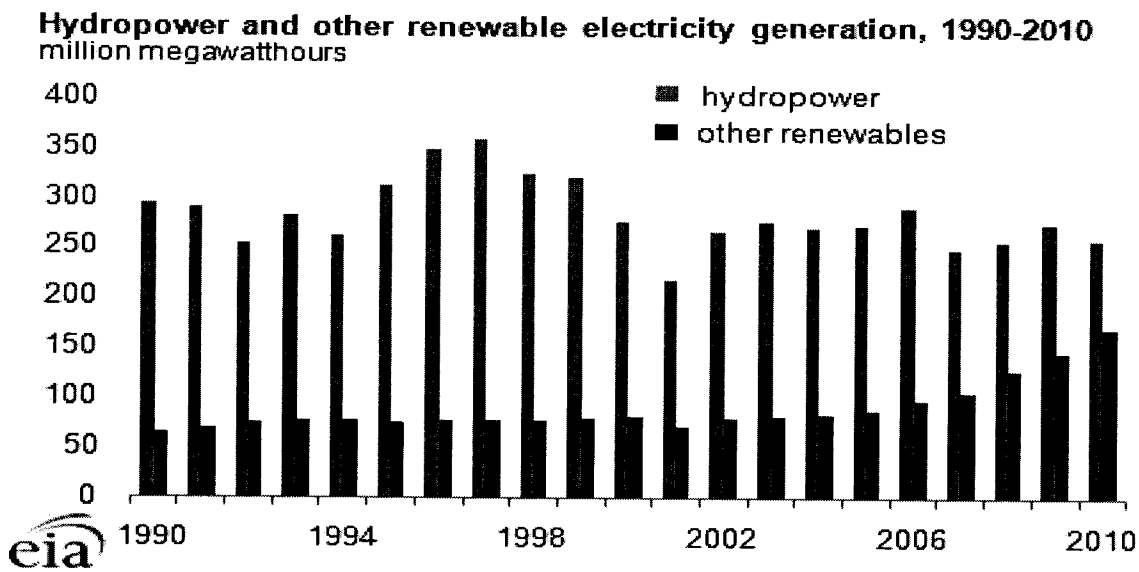
Hydroelectric Energy

Hydroelectric methods of energy generation are currently the most utilized source of sustainable energy today (Hydroelectric, 2010). Hydroelectric energy generation is obtained by using the motion of falling or moving water to turn a turbine to create an electrical current. In this, anywhere with a naturally sustainable source of aquatic motion may be employed. The utilization of this transformation of water motion into mechanical motion has been known to humanity for millenniums. Some of the first applications of this technology were employed by the ancient Greeks and Romans. They used water power to operate their mills and feed their populations around two thousand years ago (History of Hydropower, 2008). Now giant dams are constructed and equipped with equally impressive turbines to harness these same natural forces to power the modern world.

There are many advantages to hydroelectric energy. Because these are usually based around already sustained natural waterways, hydroelectric dams provide a continuous and predictable output of energy. There is an initial sacrifice of resources necessary for the construction, but this is the property of any investment. Fossil fuels are utilized in the construction process and therefore there is an initial pollution cost associated with dams, but after construction there are virtually zero emissions from such an instillation as it become more or less part of the natural framework of the new environment. The waterway still exists with only the obstruction of the newly placed dam. Hydroelectric dams require only maintenance to maintain functionality. No other primary sources of fuel have to be purchased and therefore provide relatively cheap energy to the surrounding area.

Given the benefits of hydroelectric energy, some other complications present themselves. One of the most notable of these are that in order to operate most hydroelectric dams a reservoir must be created. This reservoir mainly consists of flooding a portion of the river directly upstream of the dam. This flooding transforms the dry land adjacent to the old river into deluged land. The dam could also prove to be disadvantages to local fish communities that rely on the river. To correct for this many dams are equipped with fish ladders in areas with this ecological concern. There also the risk of a dam failure that could result in flooding of the downstream area. However the risk of failure is associated with all power plants whether they are hydroelectric, coal fired, or nuclear.

In 1940, hydropower accounted for around forty percent of the United States electrical production (History of Hydropower, 2008). Presently, hydroelectricity accounts for only about ten percent of power production in the United States which equates to 95,000 megawatts or enough to power 28 million homes (Hydroelectric, 2011). This is not by any means a reflection on the American interest in hydroelectricity.



Once viable technology presented the opportunity to obtain power through these methods, many capitalized on the opportunity immediately. Therefore many of the most acceptable, and therefore most profitable, area were tapped. As the century progressed, fossil fuel powered electrical generation had to implement more quickly to meet the ever increasing American thirst for power from both industries and residential consumers.

Solar Energy

Since prehistoric times the sun has given light and heat to the Earth and humanity. As such it is obviously the oldest source of renewable energy. Ultimately, all of the power utilized on Earth is directly or indirectly derived from the Sun. The Sun heats the Earth unevenly, because of the tilt of the Earth's axis, with solar radiation and causes different densities that are continuously diffusing causing weather and climate on our planet. In early recorded history, society has recognized the awesome power of the sun. Writings back to 213 B.C. tell the story of Archimedes reflecting amplified sunlight from bronze shields to set Roman ships on fire in naval skirmishes (The History of Solar Energy, 2010).

As time progressed more economical applications of solar energy were discovered. In 1839,Alexandre-Edmond Becquerel discovered the photovoltaic property that directly led to the formation of the photovoltaic cell (Williams, 1960). However, the first fully functioning photovoltaic module was constructed much later in 1954 (Knier, 2002). As this technology is defined, it directly transforms photons from the sun into electrical currents. Thus electricity is produced from this unique process. Until recently, photovoltaic cells were not widely adopted primarily because of the cost involved. With the invention of modern, much more efficient techniques, this process becomes much more commercially viable. Thin film photovoltaic cells are being adopted more readily than their silicon based counterparts. Photovoltaic cells that use silicon based semi conductors are slightly more efficient at converting sunlight into usable energy however, are also much more costly as they use much more costly material (Solar energy industries association, 2009). The less expensive thin film photovoltaic cells are therefore capable of producing cheaper energy per kilowatt hour and are becoming very popular. The largest solar power facility is the Endrige Power Plant in Ontario Canada completed Monday October 4, 2010 (Chidley, 2010). It has a capacity of 80 megawatts, which can power about 12,000 homes, and required an initial investment of 400 million Canadian Dollars (Chidley, 2010). The price of photovoltaic generation is currently more expensive than tradition fossil fueled methods of generation in most locations, but the increase in resources devoted to the production of photovoltaic scales coupled with the technological breakthroughs have led to a steady decline in the price of photovoltaic energy per kilowatt hour (Solar energy industries association, 2009).

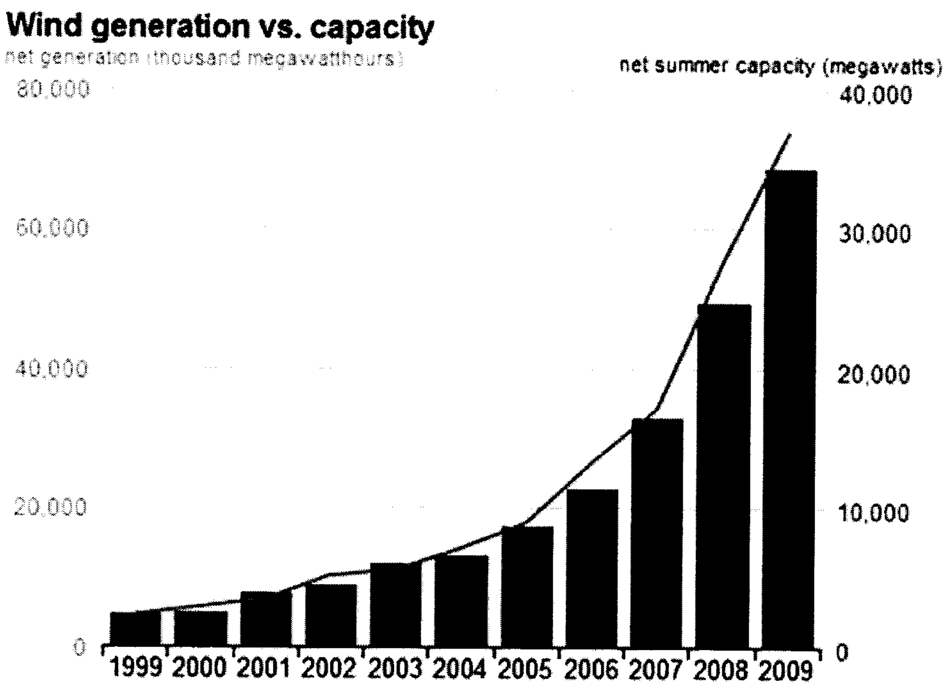
Solar thermal energy is more related to conventional power generation. Solar thermal energy is produced by concentrating solar energy to heat water that in turn creates steam that turns a turbine and generates electricity. It is a less direct method than photovoltaic cells but has been understood by civilization for far longer. In the United States this form of energy was not appreciated until the 1973 Oil Embargo. After the price of oil began to climb steeply, interest in this form of energy took off. The number of firms that made solar thermal components jumped from 45 to 225 by 1984 (Wong, 2011). This trend in increasing interest in solar energy has cyclically continued to the present. As the supply of commodities such as coal, gas and oil becomes either scarcer or less stable; interest in solar produced energy increases.

Wind Energy

Wind energy carries many similarities to hydroelectric generation. Both take advantage of the way that the fluids naturally move on Earth to transform that fluid motion into mechanical energy that may generate electricity. Ancient Egyptians first utilized these naturally occurring principals inspiring the creation of the sail to navigate ships more easily through rivers (History of Wind Energy, 2005). Later on, in Central Asia, windmills began appearing to pump water to the surface for irrigation and milling grain in the region (History of Wind Energy, 2005).

Modern notions of wind energy were apparent in the late nineteenth century as mechanical windmills began appearing for the sole purpose of producing electricity as a primary function (Price, 2009). For the most part, wind energy was harvested by farmers during the time for irrigation purposes just as they had been employed for hundreds of years previously. As with solar energy, interest focused back to this form of technology as the 1973 oil embargo forced up energy prices and oil importers began searching, or resurrecting, interest in wind energy (20% Wind Energy by 2030, 2008). In 1973, no statistics were kept for wind energy production in the United States. This is due primarily to the minute values associated with the activity. Since that time many leaps of interest and production have occurred in the field. Statistics began to be kept in 1979 and by 2008, 48 billion kilowatt hours of energy were drawn from wind sources equating to more than one percent of total energy production in the country (20% Wind Energy by 2030, 2008). In the 1990's technological breakthroughs with gearless systems and more efficient dynamos contributed to more profitable wind installations along with the steadily rising price of energy prices was suspected to have caused the increase in the production of wind energy in the last decade (Wiser & Bolinger, 2010).

Wind Energy represents perhaps the most fledgling of the energy markets presented. Thusly, there are probably the most opportunities to take advantage of this industry as it matures. Roscoe Wind Farm in Texas takes advantage of wind energy to provide the community with power (Burnett, 2010). The Roscoe Wind Farm has a production capacity of 781.5 Megawatts, or enough to power about 250,000 homes. The installed windmills occupy cropland that is still agriculturally productive while now mutually capable of producing wind power.



Source: U.S. Energy Information Administration.

Even less invasive technology takes advantage of shorelines. Offshore wind farms are becoming very popular in areas with large, concentrated populations adjacent to large bodies of water. Countries such as the United States and the United Kingdom both maintain this characteristic. While both also maintain the characteristic of very large appetites for energy and as such both are also large importers of fossil fuel resources. As such both of these countries could reap the benefits of tapping ocean winds to provide power for the adjacent trade centers.

Literature review

The topic chosen by this paper is by no means narrow in conception. As such, a broad spectrum of previously published material is available for review. The before mentioned sections elude to more general information about some of the production methods of energy. Also, personal conclusions may be drawn from said information by even the most lame and uninterested. The purpose of this literature review is to amalgamate some more scholarly ideas that proved conducive to the formation of this paper's central theme and determine what effects regimes have on production. Both societal and political information were considered alongside economic evaluation because in the case of renewable energy production this paper would like to convince the reader that these options are infinitely beneficial in the evaluation. There are very few instances of perfect information in the real world, and thusly, the inclusion of political and societal influences will hopefully prove as indispensible grounds to the inclusion and construction of such qualitative variables to help provide for more complete models presented in this paper.

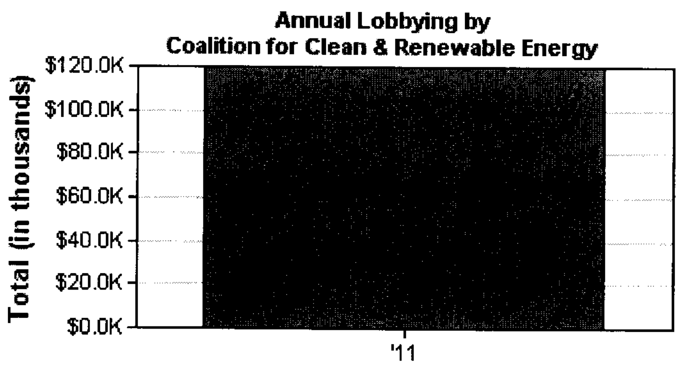
Many prominent Economists throughout modern history have recognized the unprecedented importance of using electricity in an ever advancing world. Compared to many other intellectual disciplines, Economics may seem relatively less mature. Even by the early twentieth century notice was taken on the vital importance that power production was playing in the newly developed industrial world. In short, by this time civilization had evolved fundamentally into an economy of power (Jevons, 1865). Manufacturing had come to dominate life for many people as factories provided a substantial portion of income and goods. In essence this highly industrialized capital was powering much of the modern world. In turn, electricity was powering the factories with various benefits and consequences. At the time perhaps the negative externalities that accompanied this reality were seen as completely complementary. One quite simply could not exist without the other.

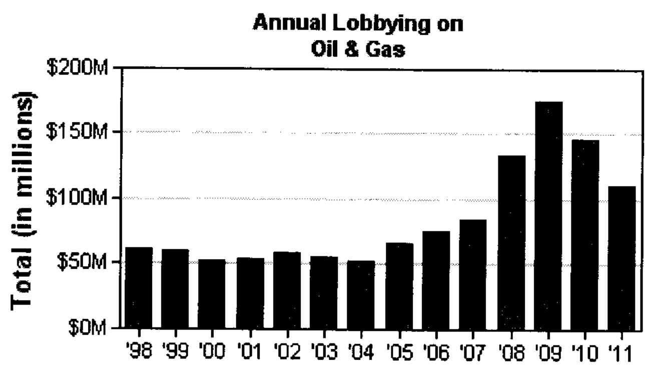
As time marched on, and specifically as the following industrial generations became more affluent, different perceptions arose. As of the present, pollution is still a major concern that is spreading to all walks of life. More attention has been vested in the increased presence of greenhouse gasses in the atmosphere and the correlation of these greenhouse gasses to the new challenges of global warming. Linking this directly to energy production, forty percent of these greenhouse emissions emanate from electrical generation (Palmer, Bernhardt, Chornesky, Collins, Dobson, Clifford, Gold &

Jacobson, 2005). Unfortunately in this aspect the trends seem to dictate the immediate future as more of the same. Just as Americans did in the previous century, Americans are becoming ever more increasingly dependent on energy (Deutch. 2005). Since this seems to be embedded in the nature of how both mature and developing economies operate, it might be moot to suggest any other circumstance will come to fruition without some unexpected and as such unbeknownst element or occurrence.

A more germane approach would be to consider energy portfolios. That is what percentage of final energy production is produced by each source respectively. The outcome is that the world will need more energy in any foreseeable future. What can be controlled by economists, politicians, consumers and producers is how we would like to accomplish the inevitable. The current portfolio for the United States heavily favors fossil fuel production (Sovacool, 2008). In 2010 renewable energy accounted for roughly eleven percent of the electricity production in the United States (Wong, 2011). The remainder was complemented with exhaustible fossil fuel generation methods. Renewable energy counts as such a minuscule fraction of production that even with active interest and proper investment the energy portfolio of the United States seems to be one of coal, gas, and oil playing a prominent role in the coming years.

One aspect of reality that both economists and politicians will generally agree on is that cheaper is better. This explains why the current portfolio may be so carbon biased. Americans have become accustomed to a lifestyle that includes cheap fuel. American politicians maintain an affinity to legislate cheap fuel for their loyal constituents (Freris, 2008). Since most politicians are not well versed in a great magnitude of sciences they have generally related this to favoring fossil fuel producers over renewable energy producers. According to opensecrets.org, oil and gas lobbying expenditures were over 110 million dollars in 2011 while the lobbing Coalition for Clean and Renewable Energy expenditures in the same year were just 120 thousand dollars.





More recent scholars have also weighed in on the prospects of future energy production. Fossil fuels will play a dominant role in the medium future of energy production (Sachs & Klaus, 2005). Renewable energy will grow as a viable platform as Americans, along with the vast majority of the world, continue to expand the already quite viable fossil fuel production base. Recently nonrenewable forms of energy enjoyed somewhat of a most favored status between the two in the United States. The current tax policies of the United States already have a carbon intensive bias (Sovacool, 2008). This is not at all to say that this bias has been unjustified. Misguided early attempts at curbing external aftermath of meeting our energy needs steered resources in many direction. Inevitably, some of these directions were less productive.

Most notably, would be an emphasis on energy conservation. Energy conservation, in most situations, does not work in the United States and therefore could not provide any meaningful remedies for our current conundrum (Deutch, 2005). This is perfectly represented by the continuing trend of Americans to become ever more energy dependant. To the dismay of such pessimistic conclusions, many authors have cited numerous eventualities that society will be challenged with tackling resulting from our incessant, increasing craving for greater quantities of energy. In a strictly American sense, two of the greatest externalities to consider are national security and global warming (Tyner, 2007). Other global powers are ascending to new levels of dominance never before witnessed, but militarily speaking the United States still maintains an air of hegemony since the fall of the Soviet Union. Recent events may speak for themselves, but given this the United States is still far from invincible. Non military factors such as Economics have exposed new unforeseen threats.

Outside of the realm of politics and Economics, global warming has recently exposed many new environmental threats. Environmental threats prove starkly different as they can neither be reasoned nor negotiated with like other actors. These environmental threats that are brought about because of our current economic patterns may be; climate change, changing ocean chemistry, habitat destruction, disease, changes in agricultural production, and increasing ocean levels (Sachs & Klaus, 2005).

Climate change is self explanatory. For thousands of years cities, towns, and people have become accustomed to specific climates in every habitable portion of the world. Now as overall temperature climb upwards, everything living will have to adapt or alternatively face certain destruction. As for the oceans, they make up a majority of the Earth's surface and play a pivotal role in stabilizing climate. When ocean chemistry changes the behavior of the oceans also changes. Everything from winds and tide to wildlife are now alternating from the accustomed norms. When considering a creature such as humans that have become very adept at exploiting what is known about these patterns for our benefits, this threat could not be placed into a bigger scope. Habitat destruction is one of the challenges that are most directly affected by human activity.

As we develop, produce, and pollute; environments suffer from the reactions. The major economic concern would be that along with these habitats, we are depleting our stock of natural resources. Plants and animals interact with the economy just as office buildings, factories and supermarkets do. Losing these natural resources means that less will be available for future economic activity. With the changes in habitat, climate, and ocean chemistry, new diseases will be able to flourish where environmental conditions had earlier not permitted. Most of the developed world lies in temperate zones where this may seem less threatening, but much of the world's population lies in the developing world where the effects on human life could be enormous. One worry for the developed world would be the resulting change in agricultural productivity. Most developed countries place an exceptionally high imperative on domestic production of food supply. Even with the growing global acceptance of freer trade, food production in almost every part of the world remains heavily subsidized and/or protected. Many staples such as rice, corn, and wheat will only grow under certain environmental conditions, in certain soils, and with certain amounts of sunlight and precipitation. As these elements of production continue to change, institutional economic frameworks will no longer function as they have before opening up possibilities for many calamities such as famine and conflict. Lastly, and perhaps most obviously, another danger of global warming is raising ocean levels. Much of the world's population is located on the coasts and if sea levels were to rise without adequate time for these populations to prepare the results could be devastating.

One of the more interesting threats offered up in the literature was the very Western threat of deindustrialization (Sterzinger, 2007). Until recently most countries focused energy policies solely around fossil fuel. This has been the norm for so long that, hypothetically, newer renewable energy related industries were not allowed and appropriate footing to compete with their heavily entrenched and subsidized counterparts. Because of the infant nature of these industries and because of the research and development needed for such to prosper, more than likely this sort of manufacturing would have developed in western worlds. Since most countries did however focus on carbon based economies this point becomes somewhat trivial at the present. The United States has seen a trend of declining industrial output for decades. If renewable energy was embraced by a society, that society would stand likewise to benefit from a level of reindustrialization (Sterzinger, 2007).

That being said, politics is playing an expansive role in either scenario. This is somewhat true already as government plays heavy roles in these markets. When it comes to the role of government trying to foster comparative advantage, history has shown us that often the end result is simply the market being hindered as a whole from such activities. More than most markets, fears and concerns affect the energy market and often governed people call to their officials for relief (Yergin, 2006). For this reason, many aspects must be considered when attempting to render and accurate examination of the energy market.

The ocean of ideas presented to correct for all of these concerns stemming from hydrocarbon based energy production are incredibly abundant and varied. The history stretches hundreds of years to when scholars first began noticing that pollution was in fact becoming a problem and needed to be solved. A tax on the industries that pollute would seem to some to be the easiest and most apparent answer to the enigma, but what seems logical in economic theory is extremely infeasible politically. Taxing carbon would make the most economic sense (Palmer, Bernhardt, Chornesky, Collins, Dobson, Clifford, Gold & Jacobson, 2005). Taxing would create a disincentive to carbon producing activities while other alternatives existed. Such a tax would have to be implemented by policy makers and most would seem rather reluctant. With renewable energy only accounting for a little over ten percent of output at the time, this would almost inevitably raise the price of energy in most markets over the short term. For a two or four year elected official this would almost always be career suicide.

At the present, tax incentives for energy production in the United States focus on oil, gas, and fuel production (Metcalf, 2007). Modern federal funding for renewable forms of energy did not even begin until 1973 and though they have grown substantially, they barely compare to the sort of funding that is available for developing oil and gas production. The energy policy of the United States explicitly states that the largest percentage of federal subsidies to energy production is allocated to increasing the countries oil production (Metcalf, 2008). The second largest government tax expenditure is for fuel development (Metcalf, 2008). The taxes used to fund these programs are drawn primarily from gasoline and roadway taxes. While some forms of ethanol fuel are renewable and derived from corn or other grain, at the present they remain very costly and may only operate through governmental subsidies. Other countries, specifically the case of Brazil, have made ethanol cost effective by substituting grain with sugar. In the United States, ethanol has been particularly successful in areas where economic activity is greatly impacted by agriculture. Because most of the inputs for commercial electricity generation are not centrally located in specific regions there is a lack of concentrated legal efforts to push for such support for hydroelectric, wind and solar power generation.

Gauging a community's interest in renewable energy is also a difficult task that has proven problematic in past literature. Economics has borrowed from other social sciences and developed methods for determining the value of a public good such as clean air or renewable energy. Contingent valuation is typically employed in these circumstances. With the media attention that is placed on environmentalism recently, there is a hypothetical bias to this type of contingent valuation when employed to determine consumer willingness to support renewable energy (Whitehead, 2006). When questioned or surveyed about their interest in supporting cleaner forms of energy production, many feel compelled to answer a certain way. Even when the surveys are conducted correctly, respondents still feel that those who do not avidly support renewable energy are demonized by society and this inflates evaluated interest in the subject. Because of this, it is difficult to predict the price or interest in renewable energy (Nyborg, 2003). The energy market has many unique features that cause similar problems when attempts are made to economically evaluate it. For this reason there is an evident need to look at more than just economic variables (Freedman, 1983).

Economic models cannot predict or identify many types of variables that can affect the energy market. Both the oil embargo and the Iranian Revolution proved this point decades ago. To this day unpredictable events affect the world energy markets from Iraq invading Kuwait to the massive tsunami that rocked Japan. Therefore qualitative variables should also be employed when attempting to model the energy market, but are far too often ignored (Freedman, 1983). Some authors point to looking at regimes as a source of correcting for this shortcoming. For this particular market that method would seem appropriate. It requires a great degree of governmental effort to bring about any changes in these markets. There are many qualities associated with the American government that might affect the energy market. Globally this idea of qualitative variables seems infeasible as regions all over the world are in different economic circumstances and are drawn to renewable energy.

Many energy production models focus primarily on prices and costs. While these certainly should be considered in any economic study, other authors have felt that these models are missing something. The current approach ignores many social costs (Sovacool, 2008). These costs may easily be derived from the threats associated with energy production mentioned previously. Many models also ignore the role of government altogether. Depending on the time frame this may be reasonable, but for more recent analysis, government must be taken into consideration. Federal support for renewable energy began in 1973 with 300,000 dollars and has since grown to sixty-seven million dollars in 2009 (Nelson, 2009). Studies have shown that these subsidies do in fact encourage the growth of renewable energy (Metcalf, 2007). However, the greatest impact occurred whenever a consumer's rate of return on investing in renewable energy was the highest (Metcalf, 2008). Most of the subsidy spending was on consumer investment and not on commercial production. This further illustrates the need of qualitative variables to capture qualities of a political environment that are conducive to the production of renewable energy.

Other hindrances to the development of renewable energy are the sheer costs associated with the state of technology right now. It is not uncommon for the capital cost of installing renewable energy generation stations to outweigh the benefits (Sachs & Klaus, 2005). Whenever this is the case, of course, the investment will not be made. However, the technology is advancing rapidly thus lowering the per kilowatt hour cost of renewable energy investment. In the United States there is yet another obstacle. Any program outside of the Department of Defense has to follow strict procedures when receiving any state or federal assistance. Namely a high percentage of parts used must be American made. This creates a country bias that obstructs efficient markets. A more efficient outcome would result from utilizing components that are manufactured wherever the greatest comparative advantage might be found. In this scenario, natural know how is trumped by political authority. The most advantages solution offered up by some authors is simply to focus the efforts of the parties interested into research and development. Research and development is absolutely vital to the expansion of the renewable energy industry (Sachs & Klaus, 2005). Increased research and development will most certainly lead to increased efficiency. Increased efficiency will lead to lower costs and, ceterus paribus increase the rate of return.

As Metcalf stated, a high rate of return is critical to implementing this technology (Metcalf, 2008). With the institutions in place as they are in the United States, there may be more external benefits than merely more stable prices and cleaner surroundings. Adopting this renewable energy technology on a much larger scale than is currently utilized may lead to a reindustrialization as the country scrambles its resources to meet the needs of clean commercial energy production (Sterzinger, 2007). Taking all of these theories and research into consideration, a model may now be built to evaluate how more traditional and new qualitative variable cooperatively work together in renewable energy production.

Therefore utilizing all of this collected knowledge this paper will mix more traditional models with newly introduced qualitative variables. Specifically, this paper will look at what political party controls the Presidency, House of Representatives, and Senate to understand how the regimes of the United States shape renewable energy production and how the country's energy portfolio will shift as a result. Understanding this will help lead government and industry into more appropriate investments in renewable energy.

Method

In order for the hypothesis of this paper to be properly tested, data had to be collected from various reliable sources. This paper is going to look at how Republican or Democratic control over the Presidency, House and Senate relate to the growth of renewable energy production. For purposes of examination some transformations were made to the variables that represented the raw data. Monthly information was collected from January 1991 to September 2010. Primary sources for collected data were United States Energy Information Administration Independent Statistics and Analysis, United States Census Bureau Monthly Survey, Bureau of Economic Analysis, National Oceanic and Atmospheric Administration, Federal Reserve Bank, United States

Energy Information Administration Monthly Energy Review, and United States Energy Information Administration Short-Term Energy Outlook - Real Energy Prices. All of these sources are governmental agencies which builds confidence in the accuracy of the data. The remaining regressors are hand coded binary variables that capture the quality either Democratic or Republican party control over specific branches of government simultaneously. Only the Presidency, House and Senate were selected because both openly operate partisan elections. Though the Supreme Court of the United States obviously has liberal and conservative Justices, these characteristics are not supposed to play a role in the deciding of cases and therefore were omitted from this study in order to avoid complications.

Monthly data was selected because much of the data collection efforts by the federal government did not begin until 1973 and I wanted as many observations as possible. Accurate accounts of other variables did not begin until January of 1991, which is also the year and month that this paper begins its focus. Monthly data allows for more observations to be presented.

For the hand coded variables, the January after every election year were left empty losing that observation. Because new members assumed office, this avoids somewhat misleading effects. In the game of politics this timing can prove very interesting. Either legislators prepare for their forthcoming departures from public service or they may continue working. The 2010 elections showed a very ambitious congress that passed many eleventh hour bills. Characteristics such as this are unique and only occurred rarely in the timeframe captured in this study.

For some of the variables, natural logarithmic transformations were used. Taking the natural log dampens outliers and aids in smoothing out initial data. Twelve month moving averages were used to adjust all energy production numbers.

After the complete data sets were assembled and manipulated, ordinary least squares regression was utilized to interpret the effects of the independent variables of the five models. Twelve month lags were taken of each dependant variable to serve as an autoregressive parameter which greatly increased the predictive capacity of the models.

The aggregate lists of variables used in the five models combined are explained below with a brief description of the transformations performed on them.

All five models will possess almost identical independent variables that will focus four major areas of interest. The most obvious area of interest will examines by utilizing economic variables. These are meant to illustrate how renewable energy production is affected by income and various prices in the market. Income will be measured by median real GDP per capita. It would be expected that incomes are significant in determining the production of any good. Assuming that energy production exhibits the characteristics of most normal goods this is expected to have a significantly positive relationship in all cases. Another market characteristic that is expected to influence the production of renewable energy is the market interest rate. Interest rates represent the real cost of investing at any given time and therefore either encumber or eases the production process as a whole. Because the interest rate represents and explicit cost, it is expected to have a negative relationship to the production of renewable energy in all cases as all processes include capital investments. In order to account for prices and their effect on renewable energy production; the prices of residential energy, natural gas, and oil were captured and applied to these models. The price of residential energy is in essence a proxy for the reward to firms or individuals that produce all forms of energy, including but not limited to renewable energy. One would suspect that as the price of residential energy rises it would make the production more profitable and thus magnify the profitability in the market for renewable energy production. That being said, this price should be positively related to renewable energy production. On the other hand, the prices of natural gas and oil act as substitutes. Both oil and gas are used as primary fuels in electricity generation and as such compete with renewable methods. Linking this back to the profitability of renewable energy production, cheaper alternatives would decrease the incentive for the former activity and expect a negative relationship between these prices and renewable energy production.

Because of the nature of electricity use in the modern context, a demographic variable is added to the model. When specifically examining the situation of the United States, electricity is highly engrained as an essential part of life. In other regions of the world electricity is a convenience and a luxury. In the United States it is unperceivable to think of large portions of the population existing without it. Since the Great Depression, social programs have existed in this country to ensure that all of its residents have access to electricity. Consequently, increases in population are expected to increase the production of all energy including renewable energy. This variable will measure the effects of demographic pressure.

The very characteristics that would separate renewable energy production from traditional fossil fuel production, especially in recent history, are the level of externalities. All forms of fossil fuel combustion generate a certain degree of pollution that is deemed harmful to society. Some of the many consequences of this pollution are; acid rain destroying property, higher costs associated with cleaning potable water, and adverse health consequences associated with pollution. The renewable forms of electricity generation examined in this study exhibit none of these properties. Since renewable energy offers an alternative to these externalities perhaps pollution may increase societies taste for these methods of production.

Political variables are also considered as independent variables in these models. When examining maps that outline wind and solar resources available to the world, it becomes clear that these industries are not sprouting and developing in the regions of the world that have the most resources available. This could very well be due to the structures and institutions enacted in regions. Because of this, political variables become interesting. The study focuses on the United States. During the time period examined in the models only the Democratic and Republican parties controlled either the legislative or executive branch of government at any given time. Four binary variables were devised to capture these qualities. They are labeled; DDD, DRR, RDD, and RDR. The first letter denotes Democratic or Republican control of the Presidency. The second letter accounts for Democratic or Republican control of the House of Representatives. The third letter is party control of the Senate. DDR, DRD and RRD would have followed suit, but accounted for zero observation and were therefore dropped. Because the focus is on Democratic control RRR was dropped as a variable.

Lrenew – This variable measures the twelve month moving of average total production of renewable energy in the United States. This variable includes all forms of renewable energy. Hydroelectric, solar and wind, biomass and geothermal are counted with this output. Information was collected from the United States Energy Information Administration Independent Statistics and Analysis. Output is measured in trillion Btu's equivalent and the logarithmic transformation was taken of this variable.

Lhydro – This variable measures the twelve month moving average of total production of commercial hydroelectric generation in the United States. It is measured in trillion Btu's equivalent, and data was collected from United States Energy Information Administration Independent Statistics and Analysis. Then a natural log transformation was performed.

Lsolar – This variable measures twelve month moving of total production of commercial solar power generation in the United States. It is measured in Trillion Btu's equivalent, and data was collected from United States Energy Information Administration Independent Statistics and Analysis. A logarithmic transformation was performed on this variable.

Lwind – This variable measures twelve month moving of total production of commercial wind power generation in the United States. It is measured in trillion Btu's equivalent, and data was collected from United States Energy Information Administration Independent Statistics and Analysis. A logarithmic transformation was performed on this variable.

Lother - This variable was produced by subtracting the outputs of hydro, wind and solar from total renewable energy output and adjusting with a twelve month moving average. It measures production of commercial biomass and geothermal energy generation in the United States. It is measured in trillion Btu's equivalent, and data was collected from United States Energy Information Administration Independent Statistics and Analysis. A logarithmic transformation was performed on this variable.

Laglrenew – This variable is an autoregressive variable that takes the twelve month lag of "lrenew." A positive relationship is expected because the output of total renewable energy this month should be a product of previously installed total renewable energy capacity plus the creation of new physical capital.

Laglhydro – This variable is an autoregressive variable that takes the twelve month lag of "lhydro." A positive relationship is expected because the output of hydroelectric energy this month should be a product of previously installed wind capacity plus the creation of new physical capital.

Laglsolar – This variable is an autoregressive variable that takes the twelve month lag of "lsolar." A positive relationship is expected because the output of solar energy this month should be a product of previously installed solar capacity plus the creation of new physical capital.

Laglwind – This variable is an autoregressive variable that takes the twelve month lag of "lwind." A positive relationship is expected because the output of wind energy this month should be a product of previously installed wind capacity plus the creation of new physical capital.

Laglother - This variable is an autoregressive variable that takes a twelve month lag of "Lother." Like the other autoregressive variables the geothermal aspect of this variable should reflect previous output plus production from new capital. The biomass aspect of this variable is less predictable because many more elements act on the production of biomass than just capital accumulation.

Lpop – This variable represents the population of the United States. It was collected from the United States Census Monthly Survey. A logarithmic transformation was performed. A positive relationship is expected because as population grows demands is thought to grow.

LGDPPC – This variable is the seasonally adjusted median gross domestic product per capita. Information was collected from the Bureau of Economic Analysis. A logarithmic transformation was performed. A positive relationship is expected because greater incomes will also increase the demand for a good.

DDD – This variable is coded "1" if the Democratic Party controlled the Presidency, House of Representatives, and Senate. This variable is coded "0" for all other observations.

DRR - This variable is coded "1" if the Democratic Party controlled the Presidency while the Republican Party controlled the House of Representatives and Senate. This variable is coded "0" for all other observations.

RDD - This variable is coded "1" if the Republican Party controlled the Presidency while the Democratic Party controlled the House of Representatives and Senate. This variable is coded "0" for all other observations.

RDR - This variable is coded "1" if the Republican Party controlled the Presidency and the Senate while the Democratic Party controlled the House of Representatives. This variable is coded "0" for all other observations.

Lco2 – This variable captures the amount of Carbon Dioxide in the atmosphere every month. Data was collected from the National Oceanic and Atmospheric Administration and is measured in Carbon Dioxide parts per million (ppm). A logarithmic transformation was performed. A positive relationship is expected because co2 represents a detrimental externality to society.

Ffi – This variable is the Federal Funds Rate. The information was collected by the Federal Reserve Bank. This is a proxy to represent the nominal cost of investing. It is expected to have a negative relationship with the regressand because as the real cost of doing business rises, the lower payout will make capitalists less willing to invest.

Resenergyp – This variable represents the mean price of residential energy per kilowatt hour in the United States measured in constant 2010 US dollars. It was collected from the United States Energy Information Administration Monthly Energy Review. It is expected to have a positive relationship to renewable energy output because this is the price received in the market or the reward to suppliers.

Pofnatgasmcf – This variable represents the mean price of natural gas per 1000 cubic feet in constant 2010 US dollars. The information was collected from the United States Energy Information Administration Short-Term Energy Outlook - Real Energy Prices. A positive relationship is expected because gas represents a substitute for the renewable energy source in all five models.

Pperbarrel – This variable represents the mean price of a barrel of oil for each month in constant 2010 US dollars. Information was collected from the United States Energy Information Administration Short-Term Energy Outlook - Real Energy Prices. Likewise, oil represents a substitute to renewable energy and is expected to maintain a positive relationship because it also represents a substitute for renewable energy.

Empirical Model

For the purposes of this study, five models are going to be introduced to investigate the topic of renewable energy production. Each will be similar in nature and process. The major dividing difference amongst their constructions will be the regressands. The five regressands will measure: total renewable energy production, hydroelectric energy production, solar energy production, wind energy production, and the last category will capture collectively biomass and geothermal energy production for the United States. The United States was chosen specifically because these models will evaluate how political qualities correspond to the production of renewable energy. Because of the author's unfamiliarity as to how foreign political regimes operate during the time period in question, only the United States was selected as to provide more meaningful interpretation of the empirical results. Knowledge of the workings of the United States government also hastened the construction, and insured the accuracy, of hand coded variables in the construction of the model.

The first model will examine the effects of the independent variables on renewable energy production as a whole. This model will include all forms of renewable energy production in the United States. For purposes of this paper; hydro, solar, and wind are examined in more detail. The last model will contain the other forms of renewable energy generation. The first model includes all forms of renewable energy production. Currently biomass accounts for a considerable portion of the United States renewable energy production. Recent issues have arisen as to the practicality of this energy source in recent months.

The other four models are similar to the first in all aspects except for the dependant variable. The hydroelectric model is specifically implemented because hydroelectricity is the most significant source of renewable energy and also because it is the most mature. The solar model is specifically looked at because of its universal potential of application. Most of the United States has the potential to produce solar power in the proper conditions. Wind is the youngest of the models and currently the most explosive in growth. At the present many consider it the most economical with current technology.

1.) Aggregate Model:

Lrenew_predicted = β0 + β1(lagltotrenew) +β2(lpop) + β3(LGDPPC) +/- β4(DDD) +/- β5(DRR) +/- β6(RDD) +/- β7(RDR) + β8(lco2) – β9(ffi) + β10(resenergyp) + β11(pofnatgasmcf) + β12(pperbarrel)

2.) Hydro Model

Lhydro_predicted = β0 + β1(laglhydro) +β2(lpop) + β3(LGDPPC) +/- β4(DDD) +/- β5(DRR) +/- β6(RDD) +/- β7(RDR) + β8(lco2) – β9(ffi) + β10(resenergyp) + β11(pofnatgasmcf) + β12(pperbarrel)

3.) Solar Model

Lsolar_predicted = β0 + β1(laglsolar) +β2(lpop) + β3(LGDPPC) +/- β4(DDD) +/- β5(DRR) +/- β6(RDD) +/- β7(RDR) + β8(lco2) – β9(ffi) + β10(resenergyp) + β11(pofnatgasmcf) + β12(pperbarrel)

4.) Wind Model

Lwind_predicted = β0 + β1(laglwind) +β2(lpop) + β3(LGDPPC) +/- β4(DDD) +/- β5(DRR) +/- β6(RDD) +/- β7(RDR) + β8(lco2) – β9(ffi) + β10(resenergyp) + β11(pofnatgasmcf) + β12(pperbarrel)

5.) Other Model

Lother_predicted = β0 + β1(laglother) +β2(lpop) + β3(LGDPPC) +/- β4(DDD) +/- β5(DRR) +/- β6(RDD) +/- β7(RDR) + β8(lco2) – β9(ffi) + β10(resenergyp) + β11(pofnatgasmcf) + β12(pperbarrel)

The table below lays out the expected signs of coefficients between variables:

regressand/reggressor	Lrenew	Lhydro	Lsolar	Lwind	Lother
Laglrenew	+				
Laglhydro		+			
Laglsolar			+		
Laglwind				+	
Laglother					+
Lpop	+	+	+	+	+
LGDPPC	+	+	+	+	+
DDD	+/-	+/-	+/-	+/-	+/-
DRR	+/-	+/-	+/-	+/-	+/-
RDD	+/-	+/-	+/-	+/-	+/-
RDR	+/-	+/-	+/-	+/-	+/-
Co2ppm	+	+	+	+	+

Co2ppm2	+	+	+	+	+
Ffi	-	-	-	-	-
Resenergyp	+	+	+	+	+
Pofnatgasmcf	+	+	+	+	+
Pperbarrel	+	+	+	+	+

Empirical Results

The overview of all five models is quite interesting. When examining F-values and Adjusted R squared statistics, all of the models exhibited acceptable, pertinent results. F values ranged from 76.07 to 1760.16 and adjusted R squared values ranged from .8161 to 0.9886. These factors combined hint at models that may be accurately employed to explain current trends or forecast future trends.

For the aggregate model, the adjusted R squared statistic was 0.8669 suggesting that about eighty-seven percent of the time the fitted regression equation explains the variation in the aggregate renewable energy production. This model also carried an F-value of 111.16 indicating that the independent variables adequately defined the dependant variable of total renewable energy output. As for the regressors, one of the variables, DDD, proved significant at the one percent level or better. Eight variables were significant at the 0.001 percent level; laglrenew, lpop, lgdppc, RDD, RDR, resenergyp, pofnatgasmcf, and pperbarrel. When specifically examining the qualitative regime variables, DDD, RDD, and RDR have statistically significant impacts on the production of renewable energy. All carried a negative signs. The largest value was

DDD and the smallest value was RDR. Lgdppc and Pofnatgasmcf were significant and negative contrary to what was expected. The sign of Lgdppc was confirmed by running two more models dropping Pofnatgasmcf and Pperbarrel one at a time. The same was done to examine Pofnatgasmcf however when Pperbarrel was dropped the sign remained positive but became insignificant. Perhaps the explanation for some of these contrary outcomes stem from renewable energy accounting for such a small proportion of the economy.

For the hydro model, the adjusted R squared statistic was 0.8161. This model also carried an F-value of 76.07 indicating that the independent variables adequately defined the dependant variable of hydro electric energy output. As for the regressors two of the variables, resenergyp and pofnatgasmcf, proved significant at the five percent level or better. One variable, Lgdppc, proved significant at the one percent level. Five variables were significant at the 0.001 percent level; Laglhydro, Lpop, DDD, RDD, and RDR. Like in the previous model Lgdppc and Pofnatgasmcf was significant and negatively signed. The same procedure was done rerunning the models dropping Pperbarrel and Pofnatgasmcf one at a time. When Pperbarrel was dropped, Pofnatgasmcf remained significant and negative. Lgdppc also remained significant and negative. With these conclusions, it should be noted that hydroelectric is the most particular of the sources of energy examined. For hydroelectricity to be plausible and profitable location must be suitable for a dam. Wind and solar are dependent on location, but also possess more flexibility.

For the solar model, the adjusted R squared statistic was 0.9905 suggesting that the fitted regression equation explains about ninety-nine percent of the variation in solar energy production. This model also carried an F-value of 1760.16 indicating that the independent variables define the dependant variable very well. As for the regressors, ten of the variables proved highly significant at the .001 level; Laglsolar, lpop, Lgdppc, DDD, DRR, RDD, RDR, ffi, resenergyp, and pofnatgasmcf. Like the other models, Lgdppc proved negatively signed and significant. When dropping Pofnatgasmcf, Lgdppc remains significant but the sign switches to positive. When Pperbarrel is dropped, Lgdppc remains significant and negative. For this model all of the binary regime variables are significant and positive.

For the wind model, the adjusted R squared statistic was 0.9886. This model also carried an F-value of 1471.92 indicating that this model most accurately describes output of any of the models. As for the regressors; one variable, DDD, was significant at the five percent level. One variable, RDD, was also significant at the one percent level. Six variables were highly significant at the .001 level; Lpop, DRR, RDR, Resenergyp, Pofnatgasmcf, and Pperbarrel. Pofnatgasmcf was signed negatively. When rerunning the model dropping pperbarrel, Pofnatgasmcf become insignificant and negative. Like the solar model all the binary regime variables in this model were significant. Contrary to the solar model all were negatively signed. The largest value was DDD and the smallest value was DRR.

Incremental F-tests were also conducted to further evaluate the binary regime variables specifically. The null hypothesis for each model presented was DDD=DRR=RDD==RDR=0. For all of the models the null was rejected. The F-values ranged from 16.78 to 54.24 and therefore relatively robust.

Policy Implications

Combining the empirical conclusions with the results of the 2010 elections, a Democratic President is finishing up his four year term from 2008, and Republicans gained the House of Representatives while the Democrats kept their majority in the Senate. This creates a problem in the interpretation of these models. This situation would have been represented by the variable DRD. DRD was not included in the models because it did not occur in the data set. However, elections are held every two years in the United States and these models incorporate the dynamics of the system. Other political factors must be considered as well. As austerity measures become more popular in the United States, this could hinder federal funding of renewable energy projects. Renewable energy is a non partisan issue. The rhetoric of both parties sees the propagation of this industry as beneficial to the country and their self interest. Austerity measures in the United States are primarily originating from Republicans. Most of the areas of the United States that could benefit the most from the existing technological status of these industries are in the red corridor stretching down the western middle of the continental United States. It would seem incredibly unlikely that these programs would become underfunded or highly scrutinized.

Conclusion

The importance of renewable energy production in the near future cannot be overstated. The world cannot possibly continue its current energy production methods indefinitely. Prices and policy are slowly guiding us toward a future where a greater percentage of our energy portfolio originates from renewable methods. Those who favor an increase in the utilization of renewable energy would have a vested interest in supporting democratic Presidential hopefuls. Sachs stated that for the next half century the world will still depend on fossil fuels. For the near future this is almost certainly true barring some dramatic shift in global affairs. However, the energy portfolio is going to marginally favor renewable growth during this same timeframe and regime factors are going to account for some of this growth prediction. However, for the near future as it exists presently, the change will be slow and mildly predictable based on empirical research.

Recommendations

Interest in Energy statistics really began in the 1970's. With the passage of time more information will become available and offer more available data to be analyzed for insight. Interest in the subject has been cyclical during this same time period. As more time becomes available accurate predictions may be made for the farther off future. For right now, this particular study is only focusing on the nearer future. The future might also allow for evaluations of regimes that were not present in the gathered data (DDR, DRD, and RRD).

Although the United States is a major player in the global energy market, more insight on the global scale could be more utilizable. A hindrance was presented to the author because of lack of knowledge on the intricate workings of foreign government operations. With a greater understanding of how qualitative variables for foreign regimes might affect the global market, useful information could be divined to guide and predict the future behavior of such large multinational organizations that also guide the process of energy production such as General Electric and Siemens.

Coal prices would have provided quite a great compliment for cost data. Especially since coal provides for a majority of power generation in the United States. For purposes of this study, data involving coal costs were conflicting and therefore left out in an attempt to not bias the results with unreliable or inaccurate data. This data was excluded from this paper.

Appendix

Table of Summary Statistics

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Lrenew	226	6.270589	0.079083	6.072853	6.428374
Laglrenew	214	6.263041	0.074265	6.072853	6.400396
Lhydro	226	5.467825	0.123295	5.230217	5.729017
Laglhydro	214	5.472488	0.125011	5.230217	5.729017
Lsolar	226	1.789303	0.149432	1.658228	2.233592
Laglsolar	214	1.765317	0.112684	1.658228	2.187922
Lwind	226	1.983281	1.065566	0.693147	4.226834
Laglwind	214	1.863402	0.96294	0.693147	4.023862
lother	226	5.603552	0.07049	5.461003	5.794283
laglother	214	5.595026	0.061965	5.461003	5.734958
lpop	236	12.54952	0.060253	12.43723	12.64572
lgdppc	236	10.25228	0.118582	10.05797	10.44284
DDD	228	0.188597	0.392048	0	1
DDR	228	0	0	0	0
DRR	228	0.302632	0.460408	0	1
DRD	228	0	0	0	0
RDD	228	0.20614	0.405423	0	1
RDR	228	0.100877	0.301829	0	1
RRD	228	0	0	0	0
RRR	228	0.201754	0.402193	0	1
Lco2	236	5.915467	0.029244	5.864199	5.973657
ffi	237	3.697764	1.959407	0.11	6.91
Resenergyp	226	11.3272	0.825029	10.17	12.93917
Pofnatgasmcf	226	11.78475	2.229915	9.379167	16.39083
Pperbarrel	226	470.9681	246.4685	184.08	1220.79

Total Renew

Source	SS	df	MS	Number	Of	obs = 204
F(	12,	191)	=	111.16		
Model	1.136307	12	0.094692	Prob	>	F = 0
Residual	0.162704	191	0.000852	R-squared	=	0.8747
	Adj	R-squared	=	0.8669		
Total	1.299011	203	0.006399	Root	MSE = 0.02919	

Lrenew	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglrenew	0.395171	0.05025	7.86	0	0.296056	0.494287	
lpop	2.67609	0.432575	6.19	0	1.822853	3.529327	
lgdppc	-1.07202	0.224622	-4.77	0	-1.51508	-0.62896	
ddd	-0.05368	0.016831	-3.19	0.002	-0.08687	-0.02048	
drr	0.007588	0.017512	0.43	0.665	-0.02695	0.042129	
rdd	-0.06071	0.013294	-4.57	0	-0.08694	-0.03449	
rdr	-0.09393	0.009023	-10.41	0	-0.11173	-0.07614	
lco2	0.089226	0.344439	0.26	0.796	-0.59017	0.768618	
ffi	0.000691	0.002114	0.33	0.744	-0.00348	0.00486	
resenergyp	0.034515	0.009654	3.58	0	0.015472	0.053558	
pofnatgasmcf	-0.01657	0.004023	-4.12	0	-0.0245	-0.00863	
pperbarrel	0.000149	3.03E-05	4.93	0	8.95E-05	0.000209	
_cons	-19.5693	3.268601	-5.99	0	-26.0165	-13.1221	

Total Renew Drop Pofnatgasmcf

Source	SS	df	MS	Number	Of	obs = 204	
F(	11,	192)	=	110.54			
Model	1.121859	11	0.101987	Prob	>	F = 0	
Residual	0.177152	192	0.000923	R- squared	=	0.8636	
	Adj	R- squared	=	0.8558			
Total	1.299011	203	0.006399	Root	MSE	=	0.03038

Lrenew	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglrenew	0.331104	0.049727	6.66	0	0.233022	0.429185	
lpop	2.776946	0.449472	6.18	0	1.890408	3.663483	
lgdppc	-1.31625	0.225477	-5.84	0	-1.76098	-0.87152	
ddd	-0.01077	0.013757	-0.78	0.435	-0.0379	0.016364	
drr	0.061692	0.01205	5.12	0	0.037925	0.085459	
rdd	-0.0293	0.011332	-2.59	0.01	-0.05165	-0.00695	
rdr	-0.07827	0.008516	-9.19	0	-0.09506	-0.06147	
lco2	0.23067	0.356682	0.65	0.519	-0.47285	0.934188	
ffi	-0.00295	0.001998	-1.48	0.141	-0.00689	0.000988	
resenergyp	0.018011	0.009141	1.97	0.05	-1.9E-05	0.036041	
pperbarrel	8.03E-05	2.62E-05	3.06	0.003	2.85E-05	0.000132	
_cons	-18.7617	3.395612	-5.53	0	-25.4592	-12.0642	

Total Renew Drop Pperbarrel

Source	SS	df	MS	Number	Of	obs = 204	
F(	11,	192)	=	106.17			
Model	1.115603	11	0.101418	Prob	>	F = 0	
Residual	0.183408	192	0.000955	R-squared	=	0.8588	
	Adj	R-squared	=	0.8507			
Total	1.299011	203	0.006399	Root	MSE	=	0.03091

Lrenew	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglrenew	0.342686	0.052004	6.59	0	0.240113	0.445258	
lpop	3.359657	0.433904	7.74	0	2.503826	4.215488	
lgdppc	-1.32955	0.231342	-5.75	0	-1.78584	-0.87325	
ddd	-0.03318	0.017271	-1.92	0.056	-0.06725	0.00088	
drr	0.033539	0.017686	1.9	0.059	-0.00135	0.068423	
rdd	-0.02474	0.011767	-2.1	0.037	-0.04795	-0.00153	
rdr	-0.08983	0.009515	-9.44	0	-0.1086	-0.07107	
lco2	0.239642	0.363309	0.66	0.51	-0.47695	0.956232	
ffi	-0.00047	0.002224	-0.21	0.834	-0.00485	0.00392	
resenergyp	0.03918	0.010174	3.85	0	0.019112	0.059248	
pofnatgasmcf	-0.0056	0.00355	-1.58	0.116	-0.01261	0.001397	
_cons	-26.197	3.154948	-8.3	0	-32.4198	-19.9742	

Hydro

Source	SS	df	MS	Number	Of	obs = 204	
	F(	12,	191)	=	76.07		
Model	2.691611	12	0.224301	Prob	>	F = 0	
Residual	0.56322	191	0.002949	R-squared	=	0.827	
	Adj	R-squared	=	0.8161			
Total	3.254831	203	0.016034	Root	MSE	=	0.0543

lhydro	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglhydro	0.31085	0.058654	5.3	0	0.195157	0.426543	
lpop	2.807845	0.803301	3.5	0.001	1.223365	4.392326	
lgdppc	-1.2617	0.417447	-3.02	0.003	-2.08509	-0.4383	
ddd	-0.14798	0.029543	-5.01	0	-0.20625	-0.08971	
drr	0.00295	0.030025	0.1	0.922	-0.05627	0.062174	
rdd	-0.13731	0.025295	-5.43	0	-0.18721	-0.08742	
rdr	-0.15239	0.016106	-9.46	0	-0.18416	-0.12062	
lco2	-0.03221	0.640795	-0.05	0.96	-1.29615	1.231733	
ffi	0.003094	0.004011	0.77	0.442	-0.00482	0.011006	
resenergyp	0.041435	0.019068	2.17	0.031	0.003824	0.079046	
pofnatgasmcf	-0.01795	0.007582	-2.37	0.019	-0.0329	-0.00299	
pperbarrel	1.31E-05	5.77E-05	0.23	0.821	-0.0001	0.000127	
_cons	-18.5549	6.162527	-3.01	0.003	-30.7103	-6.39955	

Hydro Drop Pofnatgasmcf

Source	SS	df	MS	Number	Of	obs = 204	
	F(	11,	192)	=	80.54		
Model	2.67509346	11	0.24319	Prob	>	F = 0	
Residual	0.579737724	192	0.003019	R-squared	=	0.8219	
	Adj	R-squared	=	0.8117			
Total	3.25483118	203	0.016034	Root	MSE	=	0.05495

lhydro	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglhydro	0.2629288	0.055704	4.72	0	0.153058	0.3728	
lpop	2.809483	0.81287	3.46	0.001	1.206182	4.412785	
lgdppc	-1.506584	0.409238	-3.68	0	-2.31376	-0.69941	
ddd	-0.1039939	0.023237	-4.48	0	-0.14983	-0.05816	
drr	0.0583574	0.019024	3.07	0.002	0.020834	0.095881	
rdd	-0.1021458	0.020714	-4.93	0	-0.143	-0.06129	
rdr	-0.1386008	0.015194	-9.12	0	-0.16857	-0.10863	
lco2	0.1170771	0.645279	0.18	0.856	-1.15567	1.389822	
ffi	-0.0003748	0.003779	-0.1	0.921	-0.00783	0.007078	
resenergyp	0.0199198	0.016961	1.17	0.242	-0.01353	0.053374	
pperbarrel	-0.0000653	4.79E-05	-1.37	0.174	-0.00016	2.91E-05	
_cons	-16.63683	6.181774	-2.69	0.008	-28.8297	-4.44392	

Hydro Drop Pperbarrel

Source	SS	df	MS	Number	of	obs = 204	
	F(	11,	192)	=	83.39		
Model	2.69146	11	0.244678	Prob	>	F = 0	
Residual	0.563371	192	0.002934	R-squared	=	0.8269	
	Adj	R-squared	=	0.817			
Total	3.254831	203	0.016034	Root	MSE	=	0.05417

lhydro	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglhydro	0.306824	0.055747	5.5	0	0.196869	0.416779	
lpop	2.856987	0.771415	3.7	0	1.335451	4.378523	
lgdppc	-1.28232	0.406352	-3.16	0.002	-2.0838	-0.48083	
ddd	-0.14615	0.028335	-5.16	0	-0.20204	-0.09026	
drr	0.005253	0.028175	0.19	0.852	-0.05032	0.060825	
rdd	-0.13402	0.020633	-6.5	0	-0.17472	-0.09333	
rdr	-0.15221	0.016047	-9.49	0	-0.18386	-0.12056	
lco2	-0.01946	0.636729	-0.03	0.976	-1.27534	1.23642	
ffi	0.003038	0.003994	0.76	0.448	-0.00484	0.010915	
resenergyp	0.041453	0.019021	2.18	0.031	0.003937	0.078969	
pofnatgasmcf	-0.01696	0.006196	-2.74	0.007	-0.02918	-0.00474	
_cons	-19.0208	5.793272	-3.28	0.001	-30.4475	-7.5942	

Solar

Source	SS	df	MS	Number	Of	obs = 204	
	F(	12,	191)	=	1760.16		
Model	4.42593245	12	0.368828	Prob	>	F = 0	
Residual	0.04002264	191	0.00021	R- squared	=	0.991	
	Adj	R-squared	=	0.9905			
Total	4.46595509	203	0.022	Root	MSE	=	0.01448

lsolar	Coef.	Std.	Err.	T	P>t	[95%	Conf.	Ir
laglsolar	0.7826643	0.0424788	18.42	0	0.6988765	0.8664522		
lpop	1.60374	0.2663449	6.02	0	1.078384	2.129095		
lgdppc	-0.482751	0.114102	-4.23	0	-0.7078129	-0.2576892		
ddd	0.0789193	0.0079223	9.96	0	0.0632929	0.0945458		
drr	0.0915298	0.0086738	10.55	0	0.074421	0.1086386		
rdd	0.0719775	0.0062021	11.61	0	0.059744	0.084211		
rdr	0.0201395	0.0050302	4	0	0.0102177	0.0300614		
lco2	0.0024247	0.1711672	0.01	0.989	-0.3351961	0.3400456		
ffi	-0.010333	0.0010415	-9.92	0	-0.0123874	-0.0082787		
resenergyp	0.0388493	0.0055574	6.99	0	0.0278875	0.0498111		
pofnatgasmcf	0.0182116	0.0023082	7.89	0	0.0136588	0.0227644		
pperbarrel	-0.0000321	0.0000161	-1.99	0.048	-0.0000639	-0.000000259		
_cons	-15.44306	2.388818	-6.46	0	-20.15492	-10.73121		

Solar Drop Pofnatgasmcf

Source	SS	df	MS	Number	Of	obs = 204	
	F(	11,	192)	=	1451.46		
Model	4.4128878	11	0.401172	Prob	>	F = 0	
Residual	0.0530673	192	0.000276	R-squared	=	0.9881	
	Adj	R-squared	=	0.9874			
Total	4.4659551	203	0.022	Root	MSE	=	0.01663

lsolar	Coef.	Std.	Err.	T	P>t	[95%	Conf.	Inter
laglsolar	0.591726	0.0400955	14.76	0	0.5126417	0.6708103		
lpop	2.280023	0.2896215	7.87	0	1.708775	2.851272		
lgdppc	0.4067768	0.1305774	-3.12	0.002	-0.6643272	-0.1492264		
ddd	0.0698652	0.0090027	7.76	0	0.0521082	0.0876221		
drr	0.0828544	0.0098814	8.38	0	0.0633643	0.1023445		
rdd	0.0467676	0.0061051	7.66	0	0.0347259	0.0588093		
rdr	0.0218205	0.0057719	3.78	0	0.010436	0.033205		
lco2	0.0519425	0.1964243	-0.26	0.792	-0.4393691	0.335484		
ffi	0.0074849	0.001122	-6.67	0	-0.009698	-0.0052718		
resenergyp	0.0642302	0.0052047	12.34	0	0.0539645	0.0744959		
pperbarrel	0.000048	0.0000144	3.34	0.001	0.0000196	0.0000765		
_cons	-24.16878	2.431817	-9.94	0	-28.96529	-19.37227		

Solar Drop Pperbarrel

Source	SS	df	MS	Number	of	obs = 204	
	F(	11,	192)	=	1890.72		
Model	4.425104	11	0.402282	Prob	>	F = 0	
Residual	0.040851	192	0.000213	R-squared	=	0.9909	
	Adj	R-squared	=	0.9903			
Total	4.465955	203	0.022	Root	MSE	=	0.01459

lsolar	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglsolar	0.747404	0.038897	19.22	0	0.670684	0.824124	
lpop	1.616811	0.268304	6.03	0	1.087608	2.146013	
lgdppc	-0.45787	0.114283	-4.01	0	-0.68328	-0.23246	
ddd	0.079951	0.007966	10.04	0	0.06424	0.095663	
drr	0.093316	0.008693	10.73	0	0.07617	0.110463	
rdd	0.065399	0.005286	12.37	0	0.054972	0.075826	
rdr	0.022066	0.004974	4.44	0	0.012255	0.031876	
lco2	-0.01413	0.172275	-0.08	0.935	-0.35393	0.32566	
ffi	-0.01014	0.001045	-9.71	0	-0.01221	-0.00808	
resenergyp	0.040165	0.00556	7.22	0	0.029198	0.051132	
pofnatgasmcf	0.015323	0.001808	8.48	0	0.011758	0.018888	
_cons	-15.6993	2.403622	-6.53	0	-20.4402	-10.9584	

Wind

Source	SS	df	MS				
	F(	12,	191)	Number	Of	obs = 204	
				=	1471.92		
Model	225.723685	12	18.81031	Prob	>	F = 0	
				R-			
Residual	2.44087878	191	0.012779	squared	=	0.9893	
	Adj	R-squared	=	0.9886			
Total	228.164563	203	1.123963	Root	MSE	=	0.11305

lwind	Coef.	Std.	Err.	t	P>t	[95%	Conf.	Ir
laglwind	-0.0531671	0.0738529	-0.72	0.472	-0.1988391	0.092505		
lpop	22.51042	2.274305	9.9	0	18.02444	26.9964		
lgdppc	-1.107843	0.8721159	-1.27	0.206	-2.828058	0.6123728		
ddd	-0.1297468	0.0591409	-2.19	0.029	-0.2463999	-0.0130936		
drr	-0.4575106	0.0657453	-6.96	0	-0.5871907	-0.3278304		
rdd	-0.1637716	0.0518388	-3.16	0.002	-0.2660217	-0.0615215		
rdr	-0.1330537	0.0384899	-3.46	0.001	-0.2089736	-0.0571338		
lco2	-0.2524831	1.335113	-0.19	0.85	-2.885944	2.380977		
ffi	-0.013642	0.0081215	-1.68	0.095	-0.0296614	0.0023774		
resenergyp	0.398778	0.0527974	7.55	0	0.2946372	0.5029188		
pofnatgasmcf	-0.0821134	0.016679	-4.92	0	-0.115012	-0.0492148		
pperbarrel	0.0009057	0.0001257	7.2	0	0.0006577	0.0011538		
_cons	-271.4077	23.01916	-11.79	0	-316.8122	-226.0033		

Wind Drop Pofnatgasmcf

Source	SS	df	MS	Number	Of	obs = 204	
	F(	11,	192)	=	1430.4		
Model	225.413941	11	20.49218	Prob	>	F = 0	
Residual	2.75062277	192	0.014326	R-squared	=	0.9879	
	Adj	R-squared	=	0.9873			
Total	228.164563	203	1.123963	Root	MSE	=	0.11969

lwind	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglwind	0.1138792	0.0694532	1.64	0.103	-0.0231101	0.2508685	
lpop	19.21916	2.301623	8.35	0	14.67945	23.75887	
lgdppc	-1.939103	0.9059137	-2.14	0.034	-3.725924	-0.1522823	
ddd	0.0561049	0.0482016	1.16	0.246	-0.0389676	0.1511775	
drr	-0.1957204	0.0409362	-4.78	0	-0.2764629	-0.1149779	
rdd	-0.0097381	0.0437621	-0.22	0.824	-0.0960543	0.0765781	
rdr	-0.0366289	0.0350819	-1.04	0.298	-0.1058243	0.0325665	
lco2	0.1669031	1.41072	0.12	0.906	-2.615596	2.949402	
ffi	-0.0295756	0.0078867	-3.75	0	-0.0451313	-0.01402	
resenergyp	0.2481522	0.0455585	5.45	0	0.1582928	0.3380116	
pperbarrel	0.0005258	0.0001051	5	0	0.0003184	0.0007331	
_cons	-223.5233	22.08986	-10.12	0	-267.0933	-179.9533	

Wind Drop Pperbarrel

Source	SS	df	MS				
				Number	Of	obs = 204	
	F(	11,	192)	=	1265.61		
Model	225.060668	11	20.46006	Prob	>	F = 0	
Residual	3.10389539	192	0.016166	R-squared	=	0.9864	
	Adj	R-squared	=	0.9856			
Total	228.164563	203	1.123963	Root	MSE	=	0.12715

lwind	Coef.	Std. Err.	T	P>t	[95%	Conf.	Interval]
laglwind	0.1664778	0.0756529	2.2	0.029	0.01726	0.315695	
lpop	21.28687	2.550823	8.35	0	16.25563	26.3181	
lgdppc	-2.188721	0.9662612	-2.27	0.025	-4.09457	-0.28287	
ddd	-0.0053805	0.0636193	-0.08	0.933	-0.13086	0.120102	
drr	-0.2650589	0.0675637	-3.92	0	-0.39832	-0.1318	
rdd	0.0584901	0.0468497	1.25	0.213	-0.03392	0.150896	
rdr	-0.0692164	0.0421273	-1.64	0.102	-0.15231	0.013875	
lco2	0.3036232	1.499123	0.2	0.84	-2.65324	3.260488	
ffi	-0.0194148	0.0090899	-2.14	0.034	-0.03734	-0.00149	
resenergyp	0.3174416	0.0580084	5.47	0	0.203026	0.431857	
pofnatgasmcf	-0.0083761	0.01481	-0.57	0.572	-0.03759	0.020835	
_cons	-248.2715	25.63694	-9.68	0	-298.838	-197.705	

Other

Source	SS	df	MS	Numbe r	Of	obs = 204
	F(	12,	191)	=	243.76	
Model	0.96865145 4	12	0.08072 1	Prob	>	F = 0
Residual	0.06325030 4	191	0.00033 1	R- square d	=	0.9387
	Adj	R-squared	=	0.9349		
Total	1.03190176	203	0.00508 3	Root	MSE = 0.0182	

lother	Coef.	Std. Err.	T	P>t	[95%	Conf. Interval]
laglother	0.4093079	0.0586962	6.97	0	0.2935318	0.5250839
lpop	1.672974	0.2763468	6.05	0	1.127891	2.218058
lgdppc	-0.8617519	0.1406627	-6.13	0	-1.139204	-0.5843001
ddd	0.0192864	0.0113737	1.7	0.092	- 0.0031478	0.0417206
drr	0.0010701	0.0127816	0.08	0.933	- 0.0241411	0.0262813
rdd	0.0089362	0.0080506	1.11	0.268	- 0.0069434	0.0248157
rdr	-0.0585203	0.007214	-8.11	0	- 0.0727495	-0.044291
lco2	0.2044139	0.214681	0.95	0.342	- 0.2190361	0.6278639
ffi	0.0045628	0.0013024	3.5	0.001	0.001994	0.0071317
resenergyp	-0.0018639	0.0062549	-0.3	0.766	- 0.0142015	0.0104737
pofnatgasmc f	-0.0105731	0.0025885	-4.08	0	- 0.0156789	-0.0054673
pperbarrel	0.0001921	0.0000185	10.39	0	0.0001556	0.0002285
_cons	-10.01691	2.070533	-4.84	0	-14.10096	-5.932863

Other Drop Pofnatgasmcf

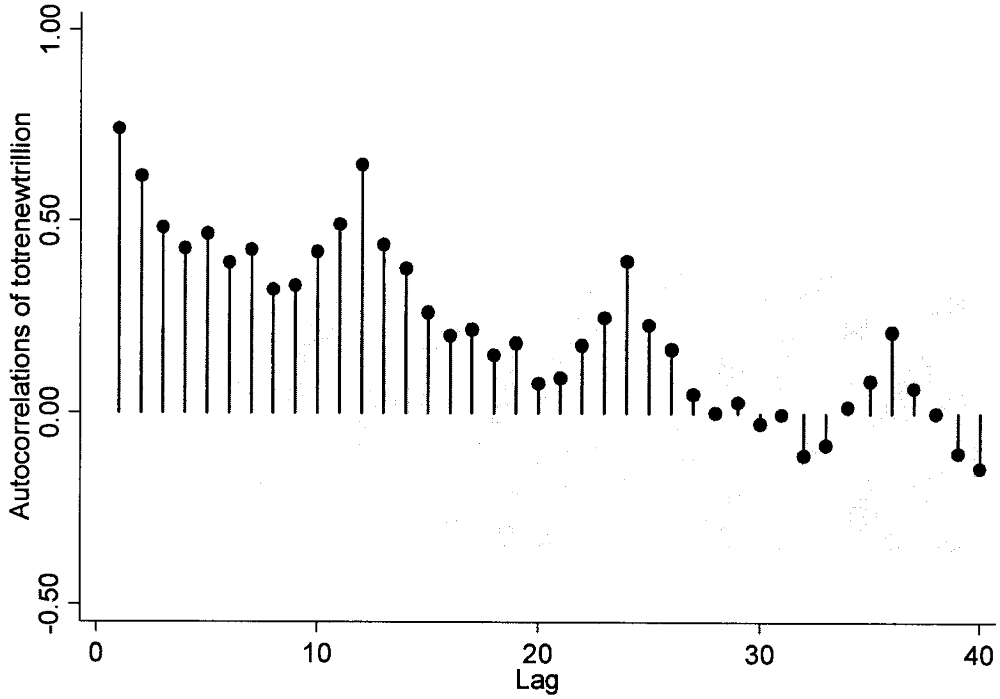
Source	SS	df	MS	Number	Of	obs = 204
	F(	11,	192)	=	244.43	
Model	0.9631265	11	0.087557	Prob	>	F = 0
Residual	0.0687753	192	0.000358	R-squared	=	0.9334
	Adj	R-squared	=	0.9295		
Total	1.0319018	203	0.005083	Root	MSE = 0.01893	

lother	Coef.	Std. Err.	T	P>t	[95%	Conf. Interval]
laglother	0.3160675	0.0562408	5.62	0	0.2051384	0.4269967
lpop	1.805748	0.285417	6.33	0	1.242792	2.368703
lgdppc	-1.023275	0.140395	-7.29	0	-1.300189	-0.7463601
ddd	0.0494353	0.0089998	5.49	0	0.0316841	0.0671865
drr	0.0402571	0.0087837	4.58	0	0.0229321	0.0575821
rdd	0.0277522	0.0068668	4.04	0	0.0142081	0.0412963
rdr	0.0434963	0.0064543	-6.74	0	-0.0562267	-0.0307659
lco2	0.2816977	0.2224083	1.27	0.207	-0.1569797	0.7203752
ffi	0.0021174	0.0012029	1.76	0.08	-0.0002552	0.00449
resenergyp	0.0081115	0.0063079	-1.29	0.2	-0.0205531	0.0043302
pperbarrel	0.0001536	0.0000165	9.29	0	0.0001209	0.0001862
_cons	-10.01309	2.153441	-4.65	0	-14.26053	-5.765647

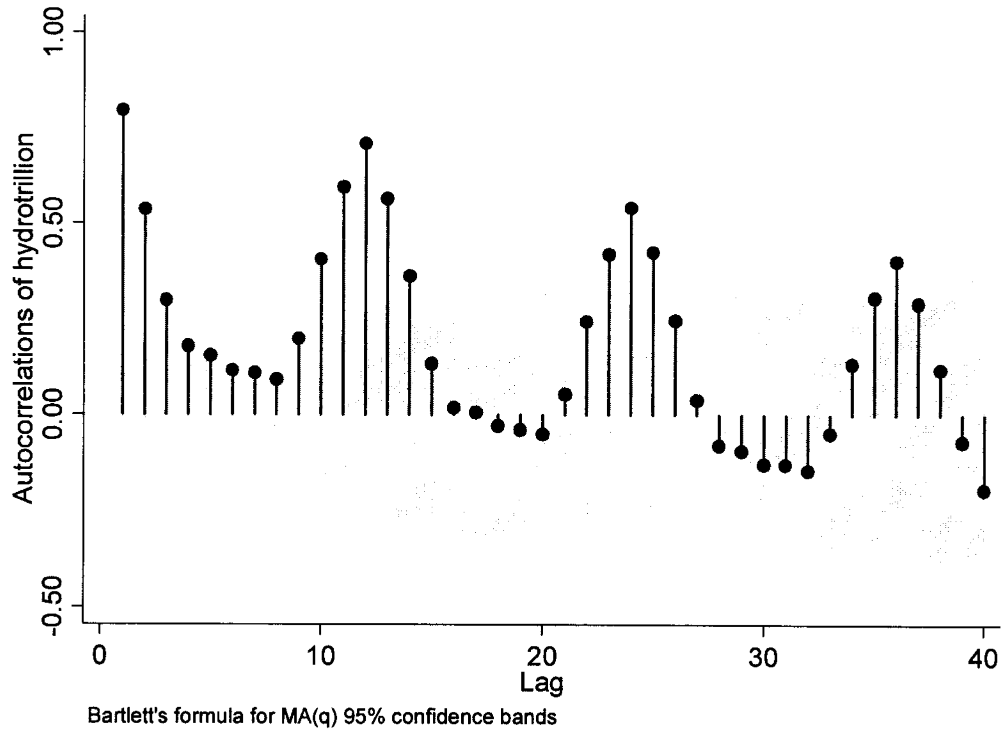
Other Drop Pperbarrel

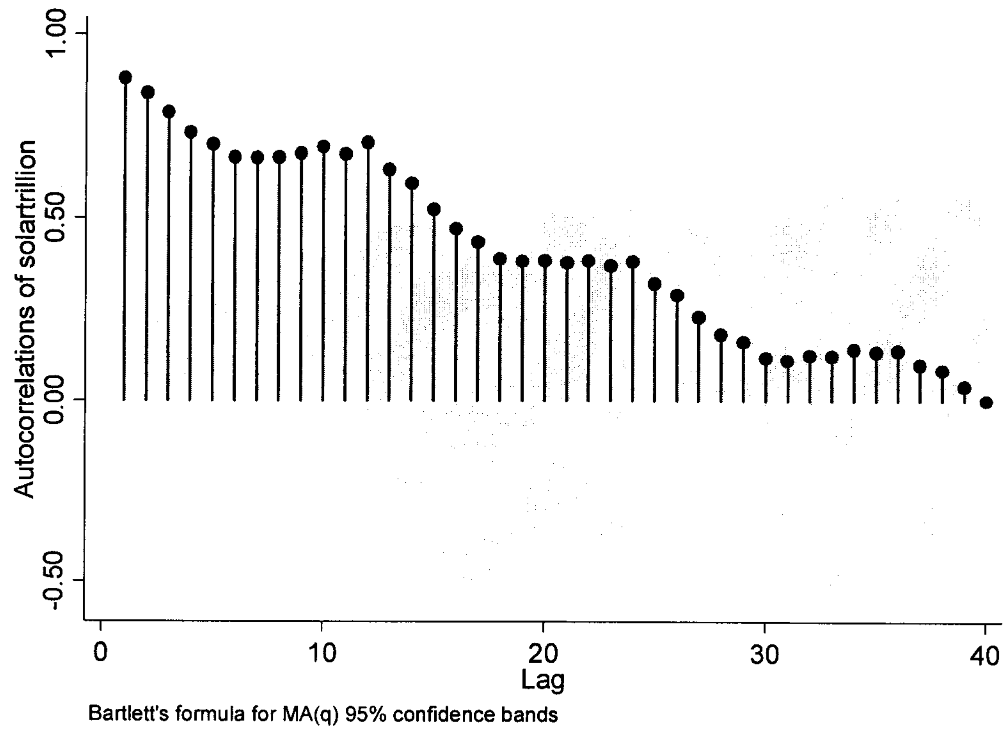
Source	SS	df	MS	Number	of	obs = 204
	F(	11,	192)	=	164.47	
Model	0.932898	11	0.084809	Prob	>	F = 0
Residual	0.099004	192	0.000516	R-squared	=	0.9041
	Adj	R-squared	=	0.8986		
Total	1.031902	203	0.005083	Root	MSE = 0.02271	

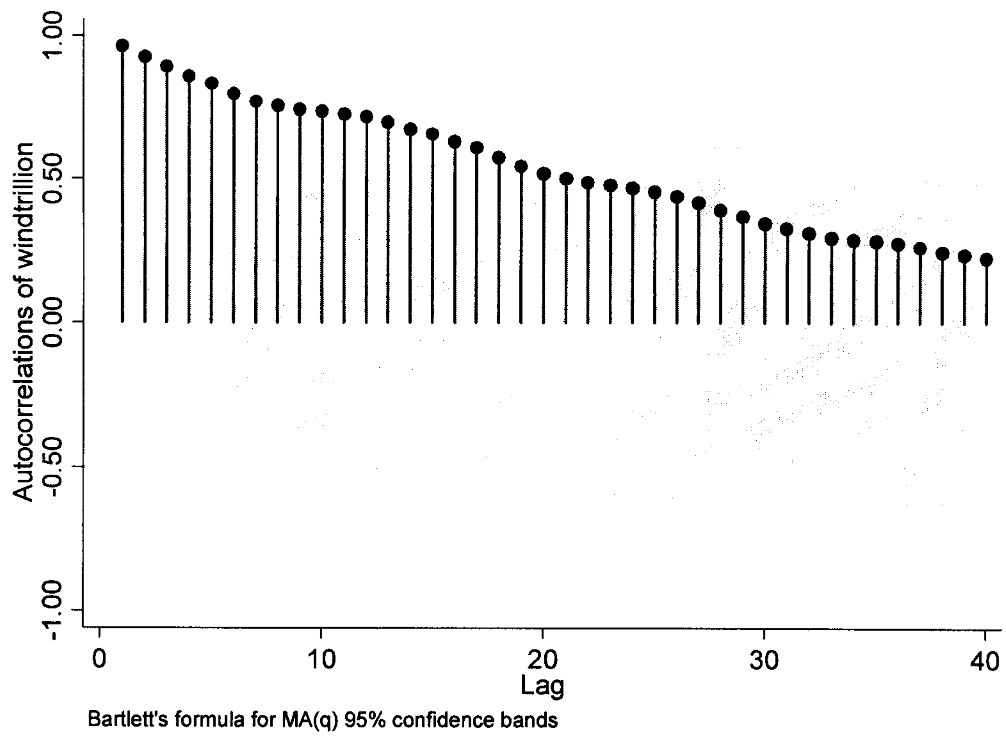
lother	Coef.	Std. Err.	T	P>t	[95%	Conf. Interval]
laglother	0.36491	0.073049	5	0	0.220828	0.508992
lpop	2.580948	0.327144	7.89	0	1.935691	3.226206
lgdppc	-1.20324	0.170667	-7.05	0	-1.53987	-0.86662
ddd	0.039399	0.013986	2.82	0.005	0.011814	0.066984
drr	0.027753	0.015624	1.78	0.077	-0.00306	0.05857
rdd	0.052031	0.00861	6.04	0	0.035048	0.069014
rdr	-0.05303	0.008978	-5.91	0	-0.07073	-0.03532
lco2	0.393184	0.266928	1.47	0.142	-0.1333	0.919671
ffi	0.002549	0.001607	1.59	0.114	-0.00062	0.005719
resenergyp	0.007163	0.00773	0.93	0.355	-0.00808	0.022409
pofnatgasmcf	0.003144	0.002779	1.13	0.259	-0.00234	0.008624
_cons	-18.9677	2.349482	-8.07	0	-23.6018	-14.3336

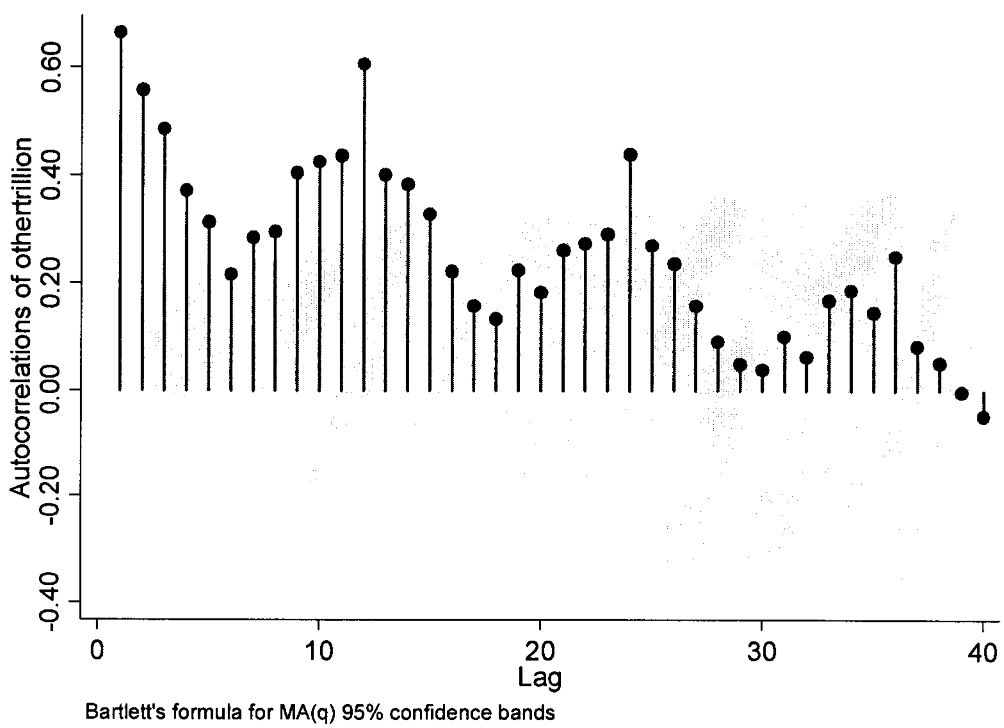


Bartlett's formula for MA(q) 95% confidence bands


Autocorrelations of hydrotrillion
1.00
0.50
0.00
-0.50
0
10
20
30
40
Lag
Bartlett's formula for MA(q) 95% confidence bands


Autocorrelations of solartrillion
1.00
0.50
0.00
-0.50
0
10
20
30
40
Lag
Bartlett's formula for MA(q) 95% confidence bands


Autocorrelations of windtrillion
-1.00
-0.50
0.00
0.50
1.00
0
10
20
30
40
Lag
Bartlett's formula for MA(q) 95% confidence bands


Autocorrelations of othertrillion
-0.40
-0.20
0.00
0.20
0.40
0.60
0
10
20
30
40
Lag
Bartlett's formula for MA(q) 95% confidence bands

F-Tests

Aggregate Model

F (4, 191) = 54.24

Prob > F = 0.0000

Hydro Model

F (4, 191) = 49.14

Prob > F = 0.0000

Solar Model

F (4,191) = 51.17

Prob > F = 0.0000

Wind Model

F (4, 191) = 16.78

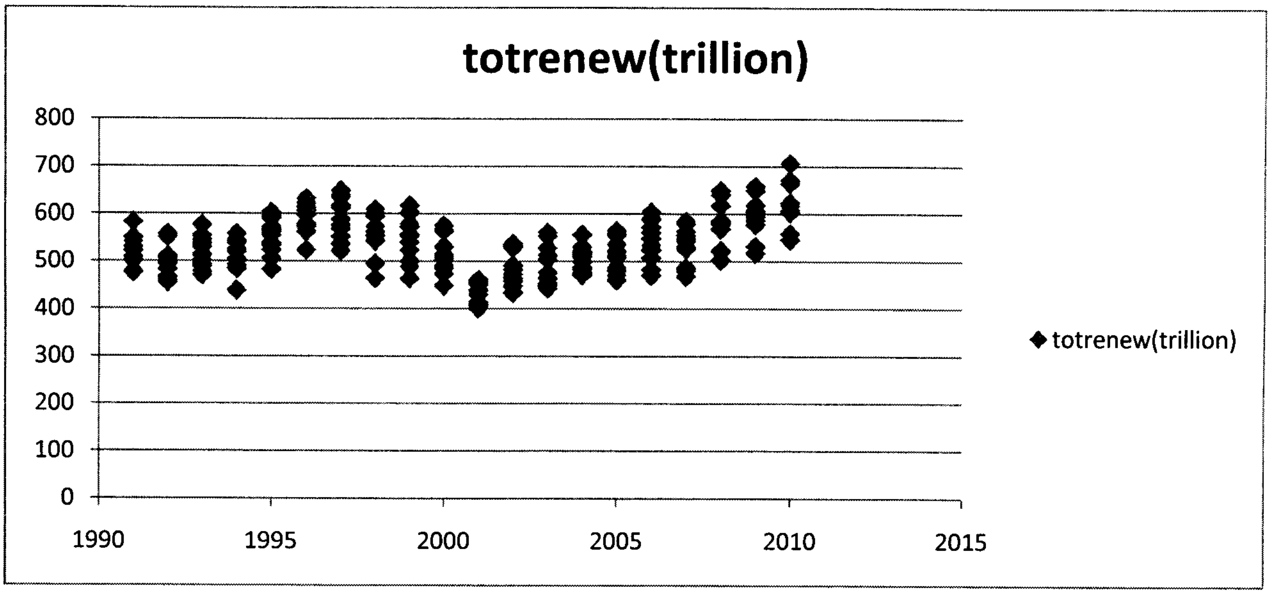
Prob > F = 0.0000

Other Renewable Energy Model

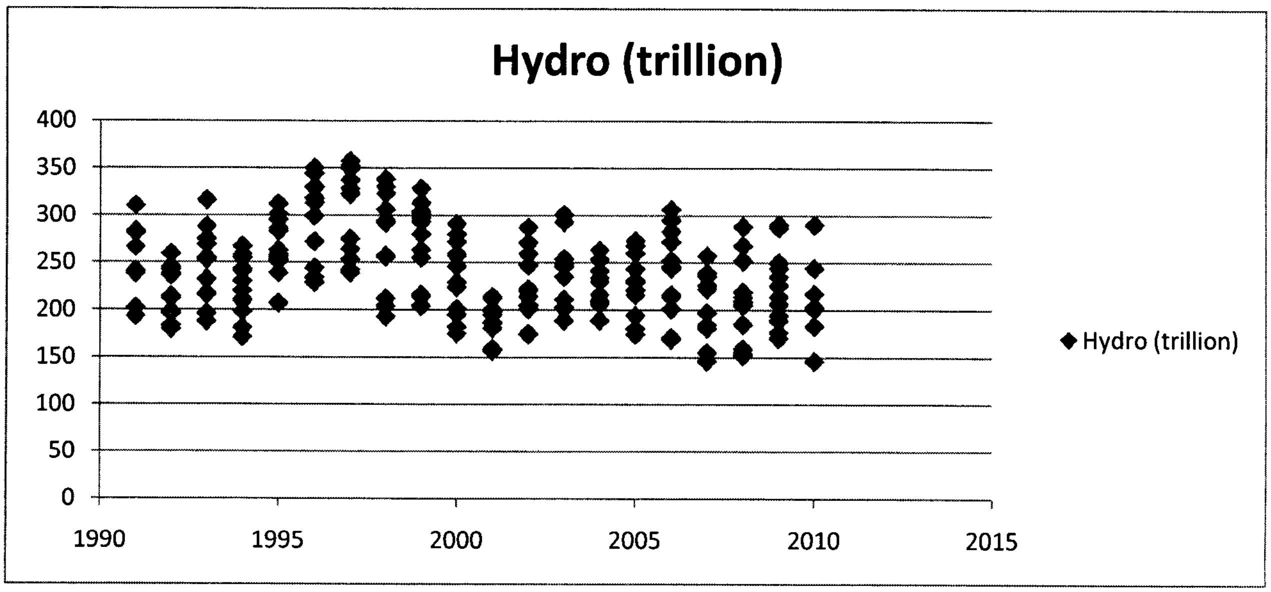
F (4, 191) = 40.46

Prob > F = 0.0000

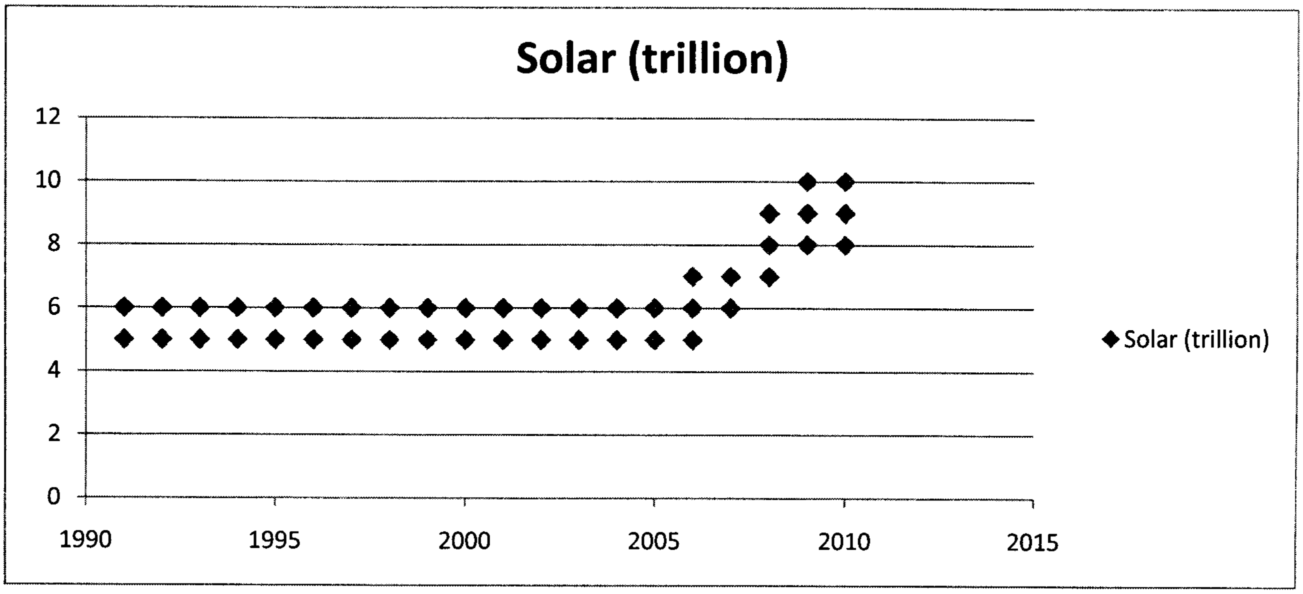
Graphs

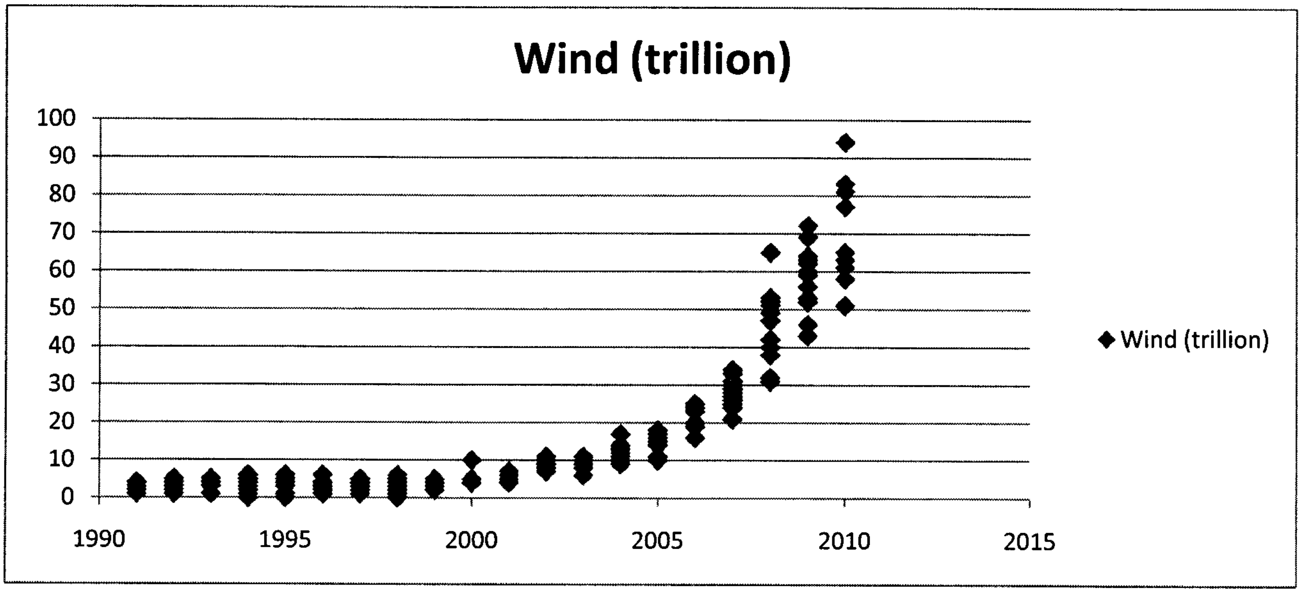


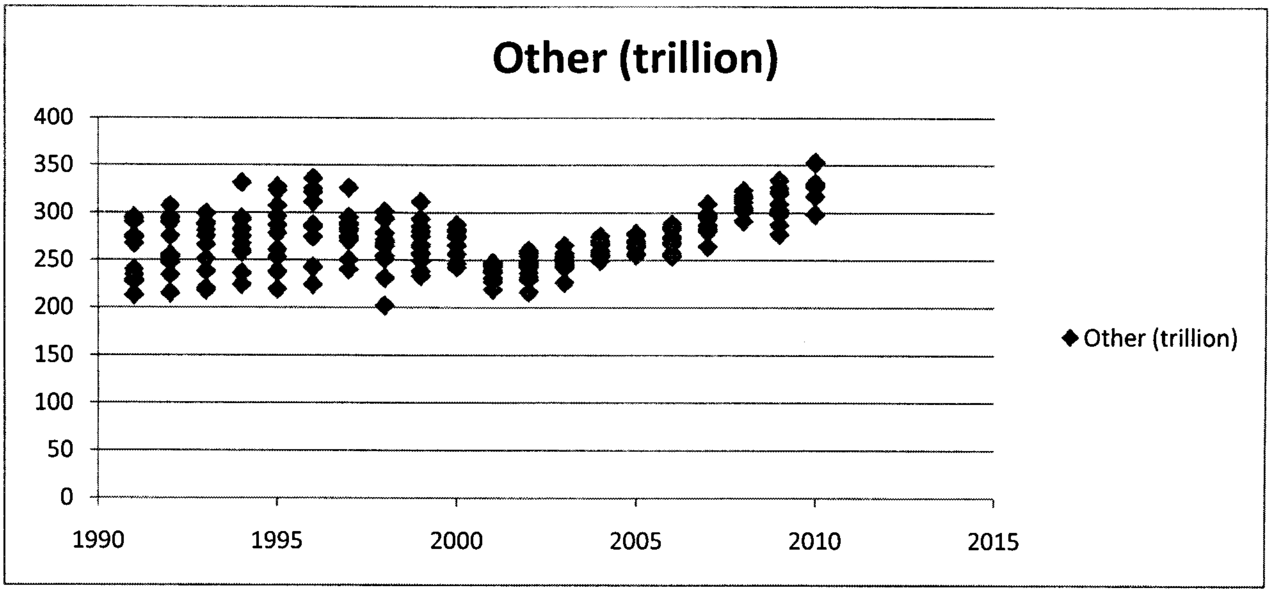
totrenew(trillion)
800
700
600
500
400
300
200
100
0
1990
1995
2000
2005
2010
2015
totrenew(trillion)



Hydro (trillion)
400
350
300
250
200
150
100
50
0
1990
1995
2000
2005
2010
2015
Hydro (trillion)


Solar (trillion)
12
10
8
6
4
2
0
1990
1995
2000
2005
2010
2015
Solar (trillion)


Wind (trillion)
100
90
80
70
60
50
40
30
20
10
0
1990
1995
2000
2005
2010
2015
Wind (trillion)



Other (trillion)
400
350
300
250
200
150
100
50
0
1990
1995
2000
2005
2010
2015
◆ Other (trillion)

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